TABLE I.—*Continued.*

Sample Positive or Negative.	Date.	Collected By.	pH.	Soil Type.	Locality.
–	17.4.51	Hannon.			Jannali.
–	17.4.51	Tehan.		Sand.	Woy Woy.
	17.4.51	Tehan.		Sand.	Woy Woy.
–	17.4.51	Hannon.			Jannali.
–	17.4.51	Hannon.		Sand.	Jannali.

TABLE II.

Date.	pH.	Soil Type.	Milligrammes of Humus per Gramme of Soil.	Number of Our Organism per Gramme of Soil.	Number of *Azotobacter* per Gramme of Soil.	Locality.
	5·5	River sand.	Nil.	Sporadic.	Nil.	Nepean River.
2.5.51	5·5	Sandy.	9·0	Sporadic.	Nil.	Rose Bay.
25.4.51	5·6	Clay.	14·0	100	Nil.	Eastwood.
20.4.51	5·62	Podsol sand.	8·6	500	Nil.	Lindfield.
10.7.51	5·65	Podsol rainforest.	80·0	100	50	Lindfield.
20.4.51	5·9	Sand.	11·4	Sporadic.	Nil.	Mt. Keira.
30.4.51	6·2	Sand.	9·0	100	Nil.	Wollstonecraft.
25.4.51	6·4	Shale.	96·0	Sporadic.	—	Haberfield.
20.4.51	6·4	Sand.	10·4	1700	1000	Rose Bay.
23.4.51	7·0	Sand.	7·2	Sporadic.	Nil.	Homebush.
23.4.51	7·0	Sand.	56·0	50	Nil.	Homebush.
7.5.51	7·0	Garden.	40·0	Nil.	830	Goulburn.

DISCUSSION AND CONCLUSION.

It is generally supposed that in the acid soils of New South Wales non-symbiotic aerobic N-fixing bacteria are absent. The fixation of N is thought to be due principally to symbiotic N fixation and anaerobic N fixation. The presence of our organism in Sydney, perhaps in other parts of New South Wales, may modify our idea of the N economy of acid soils. It is too early to generalize; only a survey of this kind on a large scale can define the distribution of this group of organisms in Australia, and assess their importance in the nitrogen economy of the soil.

In New South Wales soils, especially in the Sydney district, the organism is fairly frequent. Over 50 samples were examined and 22% gave a positive test. Comparing the results with the frequency of *Azotobacter* in Australian soils we obtain:

Author.	N.S.W.			Queensland.			Victoria.		
	Positive Soil Samples Examined.	Total Soil Samples Examined.	%	Positive Soil Samples Examined.	Total Soil Samples Examined.	%	Positive Soil Samples Examined.	Total Soil Samples Examined.	%
Jensen (1940), *Azotobacter*	37	143	25·8						
McKnight (1949), *Azotobacter*				63	143	43·15			
Swaby (1939), *Azotobacter*							21	80	26·15
Tehan	11	50	22·0						

There is no obvious correlation between the humus content of the soil and the presence or absence of our organism. In the 11 samples of soils giving a positive test the humus content ranges from nil to 96 mg. per g. Chalaust (1948) in France has pointed out that the numbers of *Azotobacter* vary with the humus content of the soil. Our results show no such relationship but they include only a small number of soils.

Other aspects of the problem may be raised. It seems possible that our organism lives mainly in sandy soils, but here, too, the number of samples is too small to give a definite conclusion. Our organism is found in soils whose pH ranges from 5·5 to 7·0.

These preliminary investigations show that acid tolerant N-fixing organisms are present in Australia, especially in the Sydney district. Their general ecology in Australia is still unknown except that the pH and humus content of soils seem to be without effect. It will be interesting to investigate the physiology of this group of organisms in relation to their ecology.

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ERNEST CLAYTON ANDREWS.
1870–1948.

(Memorial Series, No. 13.)

(With Portrait, Plate ii.)

By the death on July 1, 1948, of Ernest Clayton Andrews, geological science in Australia lost one of its outstanding figures. Modest and self-effacing, a man in whom was no guile, friendly, helpful, lovable, he left behind such a record of geological research and of unselfish service in the cause of science generally as would be hard to match. By training and experience a field-geologist, with little first-hand knowledge of laboratory methods or techniques, he sought to correlate and integrate individual facts of his own and others' observing and to establish basic principles of wide application. In this way, like David before him, he helped to break down the barriers of State boundaries that tended to keep Australian geology and geologists within unnatural water-tight compartments. His contributions to geological science were not only intrinsically valuable, but original and stimulating, and his brilliant and far-reaching generalizations provided sound foundations whereon his successors have built. He was in truth one of the pioneers.

The youngest but one of a family of seven, Andrews was born of English parents on October 18, 1870, in the Sydney suburb of Balmain, but his childhood and youth were spent at what is now Rockdale, then largely bush with scattered houses, where his father, a rather dour man of puritanical outlook and with a strong bias in favour of the so-called practical things of life, conducted a small school. So rapidly did Ernest imbibe the three R's, that at the age of seven he was set to teaching the younger pupils. Out of school hours he was kept busily employed in strictly utilitarian domestic pursuits. Happily this stern and Spartan *régime* did not embitter or warp his naturally sweet and sensitive nature, possibly because an instinctive love of beauty found an outlet in the largely enforced reading of the Bible and the entirely surreptitious perusal of such literature as he could come by. As opportunity offered he assimilated "The Canterbury Tales", "The Faery Queene", "Paradise Lost", "The Pilgrim's Progress", Macaulay's "History of England", and other classics. The literature of Greece and Rome (mainly in translation) also attracted him, and in his geological papers one occasionally comes on apt classical allusions, as when he likens the geologist to "Antaeus of old, who must draw strength from continual contact with the Earth".

The books he read were not merely to become a part of his knowledge; long passages of them he learnt by rote, to the development of a memory that was phenomenally retentive naturally. In later life when lecturing he would recite without notes dates and details of events, relying only on his memory. On the occasion of his Presidential Address to the Royal Society of New South Wales in 1922 the lights failed without warning, but Andrews, who happened at the moment to be giving biographical details of recently deceased members, calmly continued his recital without interruption in the dark.

He was almost entirely self-taught for, apart from the early years spent under his father's tuition, he had only six months at a primary school at the age of 14. During this time, however, he rose to be dux of the school and was deemed a fit candidate for the Junior Public Examination. Two years later he was appointed a pupil teacher at Hurstville, and sat for the Senior Public (roughly equivalent to the present Leaving Certificate) Examination. For this he chose geology as a tenth subject (solely, it is said, because his pen refused to scratch out the name on the Application Form), started to study it three weeks before the examination, and gained an A pass. Finishing his period as a pupil teacher, he entered the Teachers' Training College in 1891, matriculated in the same year to the University of Sydney and graduated Bachelor of Arts in 1894, geology and mathematics being among his subjects.

He was appointed to a city school, but at his own request was transferred to Bathurst, where he taught for four years. The schoolmasterly habits, early and deeply ingrained in him, persisted through life; his conversation with junior, and indeed contemporary, geologists was wont to be somewhat didactic, in the manner of one instructing the young, and in his talks before scientific gatherings he made free and frequent use of simple illustration and homely analogy.

But school-teaching was not to be his serious life-work. At the University he had fallen under the spell of Edgeworth David, the newly-appointed Professor of Geology, and his inherent love of nature was quickened by rambles with a few kindred spirits in the country around Bathurst; as a result he presented his first geological paper, "On the Geology of the Cow Flat district, near Bathurst", to the Australasian Association for the Advancement of Science at its Sydney meeting in January, 1898. About this time Professor David was asked by Professor Agassiz of the Harvard Museum of Comparative Zoology to find a young graduate capable of undertaking the collection of coral-reef material in Fiji. He chose Andrews, who, obtaining leave of absence from teaching duties, spent six months without remuneration in Fiji and Tonga with an assistant, measuring (with the aid of a coil of rope 1,100 feet long) cliff sections of coral limestone and noting the phenomena of vertical uplift so well exhibited in those islands; his report on this work was later published as a Bulletin of the Museum of Comparative Zoology. He conceived a great admiration for the kindness, honesty and navigational skill of the Fijian natives. He lived like them, ate the same food, learnt their language and accumulated much of their folklore. It was probably during this time that he acquired that interest in problems of Pacific structure which became almost a ruling passion with him in later life, and on which he was an acknowledged authority.

But the Fijian trip also opened up for him vistas of work in other geological fields. Conscious of his scientific shortcomings, he obtained leave to attend University courses in geology and chemistry, and was appointed a geologist on the Geological Survey of New South Wales on 1st July, 1899. In the Survey he remained for 32 years, filling successively higher posts till he was appointed to the position of Government Geologist in 1920. This office he held till his retirement at the end of 1931.

These years in the Geological Survey were profitable for Andrews and for geological science in Australia. Opportunities for field study came thick and fast and varied, and the young geologist, his true *métier* discovered and his ambitions in process of realization, found new avenues of investigation ever opening before him, some economic some not. The traditions of the Survey were, naturally enough, for the most part utilitarian, and though the young Edgeworth David had imported an element of "academic" geology, he had some nine years before left for the wider sphere of the University. Andrews perceived that in investigating an ore-deposit something more was needed than mere description, and he sought to discover causes and to establish basic principles. His first task, a difficult one for a tyro, was an examination of the Hillgrove mining field in Southern New England. Quite ignorant of mining terms but loth to display his ignorance, he set himself to master these while studying the intricacies of the ore-deposit and its enclosing rocks. This was the first of a series of studies of active and decadent mining fields in many parts of the State, such as Yalwal, Kiandra, Drake, Forbes–Parkes, Cobar and Canbelego, the results of which were published in the Mineral Resources series of the Geological Survey. These detailed examinations and others into the occurrence of tin, molybdenum, bismuth, wolfram and other ores in the Northern, Central and Southern Highlands, gave Andrews a thorough insight into ore-deposits, and to his restless and inquiring mind provided much food for thought on such questions as igneous petrogenesis, the origin and mode of emplacement of ore-bodies, and the conditions attending the formation of deep leads. The section on auriferous leads contained in his Forbes–Parkes report is regarded as one of the clearest and most illuminating expositions of the subject. The great New England bathyliths, with their lithological variations and evidences of successive injection, provided vivid and spectacular lessons in petrogenesis, and from an examination of them Andrews independently developed views on magmatic injection through overhead stoping virtually identical with those propounded about the same time by Professor R. A. Daly.

His last and greatest contribution to the study of the State's mineral wealth was the report on the Broken Hill silver–lead–zinc field. Despatched from Sydney to make a brief inspection of what was in official quarters regarded as a moribund field, he worked for some time single-handed, essaying the impossible task of mapping not merely the lodes themselves and their immediate environs but also the igneous and metamorphic complex in which they were emplaced. Later the mining companies subsidised the work and enabled it to be done in greater detail, so that though the responsibility remained with Andrews he had the help of a number of subordinates. Investigations were spread out over several years and eventually the results were embodied in a monumental memoir with numerous maps and sections, the most imposing of its kind ever issued by the New South Wales Department of Mines. Andrews himself had complete confidence in the future of the field, a confidence justified by the fact that now, thirty years after the issue of the Memoir, the ore-reserves in sight are at least as great as they were then.

The greatness of the report is apt to be obscured by the wealth of detail, but it is significant that twenty-five years after its publication geophysicists and geologists making intensive studes of the lodes were agreed that Andrews's views on the structures were still substantially correct. Incidentally, the lesson of the value of geological work in mining was so brought home to the mining fraternity of Broken Hill that each of the chief mines now has its own geological staff, a thing unheard of in the days before the survey.

A study that quite early attracted the interest of Andrews was that of Physiography. In the great New England plateau with its level skyline, and its peneplain surface cut into by mature valleys trenched by profound gorges, he found abundant illustrations of the principles enunciated by Gilbert, W. M. Davis and other American pioneers of geomorphology, whose writings had fired his imagination. But to his colleagues his opinions were unorthodox, heretical. On returning to Sydney after a New England trip he disclosed to a conservative senior his conviction that the great gorges there were youthful, only to meet with the chilling reply: "Oh, no, Mr. Andrews, you are quite wrong; they are very old." But Andrews, talking in terms of development rather than years, knew he was right, and his views on the history of the New England plateau, presented in a series of papers, have, with remarkably little modification, stood the test of nearly half a century. True he was unable to decide definitely whether differential erosion or faulting was responsible for the differing levels of adjacent peneplain surfaces, and for his natural enough vacillation on this point he was severely taken to task by less enterprising colleagues.

A little physiographic handbook for schools from his pen, "An Introduction to the Physical Geography of New South Wales", appeared in 1905. This expounded the main physiographic principles, with illustrations from various parts of the State, but chiefly from around Sydney. While some of its interpretations are now known to be in error, the book shows an amazing grasp of many of the physiographical features of New South Wales, though it is to be feared that some of its contents were rather above the heads of the budding geographers who had to study it.

Andrews was really the pioneer of modern physiographic studies in this State, if not in Australia. Like all pioneers, he made mistakes, but in all essentials his work forms the basis of most of the present-day conceptions of the physiographic evolution of the continent. Perhaps his crowning contribution to physiographic thought was his paper, published in 1910, on the Geographical Unity of Eastern Australia in Tertiary and post-Tertiary Time, a masterly integration and interpretation of the results of observations by himself and others. His conception of a great epoch of differential uplift—the Kosciusko Uplift—beginning about the end of the Pliocene, is now generally accepted, and has been extended to include the whole of the Australian continent. Probably many of those to whom the concept is a commonplace have forgotten who was its originator and are unaware that it was formulated less than fifty years ago.

Having lived and worked for a number of years amid river-made landscapes, he was much impressed during a visit to New Zealand by the evidences of glacial erosion in the Fiordland region. As a result he became an ardent champion of the efficacy of glacier corrasion at a time when this was seriously questioned and even forthrightly denied and decried by eminent authorities. In the *Journal of Geology* in 1906 he exposed the fallacy of judging the efficiency of Pleistocene glaciers during glacial maxima or ice-floods by the feebleness and inertness of their degenerate successors of the present day. This paper, in which he crossed swords with opponents like Fairchild, attracted favourable notice overseas, and was probably responsible for an invitation to visit the United States of America in 1908. For Andrews this trip, later extended to Britain and Europe, was full of inspiration; it afforded priceless opportunities of seeing and discussing with the foremost authorities many of the great physiographic phenomena, particularly in the Californian Sierras, where several weeks were spent in the company of Dr. G. K. Gilbert, W. D. Johnston and others. Opportunity was also afforded for meeting and discussing problems with workers in Economic Geology, Petrology and Structural Geology. Andrews always retained a warm affection for those with whom he had forgathered on the trip, and in particular often spoke of Gilbert with admiration amounting almost to hero-worship. Undoubtedly this communion with kindred spirits in other lands had a profound effect on his subsequent work.

American experiences served to confirm his belief in the efficacy of glacial erosion, and his views were embodied in three papers published between 1909 and 1912—"Corrasion by Gravity-Streams", "An Excursion to the Yosemite", and "Erosion and its Significance". The papers attracted comparatively little notice in Australia, but were warmly received in the United States of America as important and significant contributions to erosional theory. The first of them was regarded by Andrews as one of his best papers. It is perhaps unfortunate that in this, as in others of his longer papers, he was somewhat discursive, and this fact and the very close and detailed reasoning which characterizes them are apt to discourage all but the most earnest readers.

Andrews's early investigations in Fiji gave him a lasting interest in coral reefs. With his friend Charles Hedley he examined the Queensland coast and the Great Barrier Reef in 1901 in a small sailing boat, and in 1917 with W. M. Davis of Harvard he made a tour of the reefs of New Caledonia and the New Hebrides. The general question of coral reefs he discussed in his presidential address to the Royal Society of New South Wales in 1922, particularly stressing their sensitiveness and accuracy as criteria of Cainozoic earth movements within the Pacific region.

The importance of tectonic structure was strongly borne in on him during his economic investigations, particularly in the Cobar and Broken Hill fields, and structural geology, leading naturally on to palaeogeography and geological history, came to be regarded by him as of paramount importance. A number of his papers are concerned with the structural features and tectonic history of Australia and the Pacific and with the origin of mountain ranges. An undulatory theory of earth movements, often assumed but never expounded in detail, seems to have dominated his tectonic thoughts.

Preoccupation with many branches of geology by no means exhausted the intellectual activities of Andrews. To them he added a lively and knowledgeable interest in botany, particularly that of Australian native plants. Gilbert had initiated him into the botany of the Californian Sierras, and from his friends J. H. Maiden and R. H. Cambage he had imbibed a knowledge of systematic botany and an interest in Australian plant ecology and geographical distribution. Thus in some of his geological reports and notably in his Broken Hill Memoir, we find lists and illustrations of the local trees, shrubs and other plants. Nor was he content to be a systematist; he must needs be thinking of the origins and development of the plants and their bearing on geological history. So we find papers by him on the development of the Natural Order Myrtaceae (1913), and the Natural Order Leguminosae (1915), the geological history of the Australian flowering plants (1916), and the origin of the Pacific insular floras (1940). The geological importance of plant distribution he was fond of stressing. On one occasion he was giving a series of special lectures to University students on the former land-connexions of Australia. The students, long accustomed to regard a display of